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Introduction

To recognize the need for creativity in the classroom as one of the growing concerns in the educational community today is not difficult. When the various teaching methods in science are evaluated, the highly pronounced need for more creativity in science instruction is evident.

Few teachers, it seems, experiment actively with teaching techniques and curriculum materials. Most find what works for them and stick with it, and, often, this means teaching science as a lecture course (with some group discussion and a few laboratory experiences). Beginning teachers tend to imitate the persons they considered to have been their best teachers. This often results in a series of lectures supported by small quantities of laboratory work and group discussion. Teachers normally use a textbook as the central focus of the course, supplementing it with a sometimes distantly related laboratory workbook. The teacher and the textbook take on the roles of authority figures, disseminating information in a clear and forthright manner, while the laboratory serves as nothing but confirmation of what is explained in class. Workbook exercises outside of the laboratory are concerned more with vocabulary drill than with scientific process. Students are asked to memorize factual information (i.e. the history of science) and regurgitate it on examinations rather than actually experiencing science. This method of instruction is not often successful in either sparking student interest in science or promoting student action. Students cannot learn science from a book or series of lectures only. They must seek and experience science in an active manner.

The evaluation of many different styles of teaching indicates that an inductive approach is often the most beneficial to both students and teachers. Using this approach, students are encouraged to learn by discovery rather than rote memorization and regurgitation. Attempting to introduce more creativity into the classroom, however, requires that teachers be willing to depart from traditional textbooks, lesson plans and old methods.

By modifying the approaches and the material studied, inductive teaching (and the promotion of discovery learning) can be used at all levels of education. Details may vary from one level to another, but the total view of science should not change: **Science is a collection of ways of looking at the world around us and gaining new knowledge.**

In the field of science, teachers and students work with observations and facts. Students gather data by looking at things, describing them and measuring them. In doing so, they store useful pieces of information. Often while retesting and observing, students may discover that data previously considered accurate is in error. This leads to hypotheses as to *why* the information did not agree and further investigation and experimentation to test the hypotheses. In this way, students begin to master various concepts and scientific methods of exploration, developing their own creativity in searching for solutions to problems. Teachers must ask themselves if the way they teach science leads to student behavior which demonstrates mastery of concepts and creative thinking. If the answer is no, they must ask how they can change their teaching method to help develop such mastery and creativity.

Getting Started: Basic Problem Structure

The first task of any teacher is to attract the attention of the student. Once interest is aroused, the student will learn far more through his or her own efforts than the teacher could ever teach in a lecture. Experience shows that one effective way of arousing student interest is to conduct a laboratory investigation that actively involves the students. They will develop more interest through actual activity than by reading a textbook describing an activity or hearing a lecture. Textbooks and lectures offer students a large number of facts and answers, but activity leads them to seek out their own explanations, and a well structured activity (e.g. one which allows the students some amount of creative freedom in problem-solving while gently guiding them towards solutions) can result in student enthusiasm as well as success.

In structured activities, students are given instructions that lead them through a series of steps and experiments designed to produce certain specific results. Overly structured activities, however, can result in the students losing track of what they were trying to prove (even if they come out with perfect results in their experimentation). These are no more productive in the attempt to bring creativity to the classroom than demonstrations done by the teacher in front of the whole class. Both illustrate the point being studied, but neither offers much student involvement or calls upon students to utilize their own resources in finding the answers. Structured laboratory exercises should be written to guide the students toward the desired results but still require them to think about what they are doing. The procedures can be written out in complete detail, but they must include questions requiring students to analyze why the activity is being performed and why it is done in a certain way. If the students are asked to gather data, they should understand why they are gathering the data (e.g. what are they testing? what are they trying to prove?), but they need not know

in advance what the results should be. If their data differs from what was expected by the teacher, the students should not be chastised for being "wrong," but should be encouraged to investigate their procedure and discover the reason for the discrepancies.

More advanced students may be challenged using more loosely structured activities, in which the teacher poses a problem and the students devise their own plan of investigation. This allows student creativity in designing procedures, collecting and organizing data and arriving at personal conclusions. The teacher who allows students to create their own solutions to a problem may find that they come up with several different types of data and solutions.

What about the "Non-experimental" Sciences?

Not all science classes lend themselves to experimentation. This is especially the case in the fields of natural science. Controlling all of the factors involved in the study of biological forms is difficult. Instead of experimentation, however, life science classes may utilize observation of natural events to find answers. Problems requiring scientific observation should be presented and the students asked to gather and interpret basic data. This way, students discover for themselves the answers to various problems. Beyond this, students may use the data they gather to predict further events and outcomes. For example, if the plants being studied grew an additional six percent when the room temperature was increased, what will happen if the room temperature decreases? What if the room temperature is increased even more?

In order for the students to observe, classify and interpret effectively, they must be encouraged to step into the shoes of a scientist and become active participants in science. Because students cannot be expected to discover everything in science, the teacher must involve him or herself in the investigation process and guide students in the use of answers already discovered by other scientists.

The Learning Environment

To imagine things for which one has no basis in experience is impossible. This is especially true in creative/discovery learning. Teachers must constantly widen the scope of their students' learning environment to encourage the development of individual interests and abilities. Although academic settings demand structure, activities must allow students to explore freely. The science classroom should be a place where students are encouraged to seek new ideas. Science is not a textbook subject; it is an activity of people. In the classroom, science is the activity of students searching, inquiring, investigating and seeking knowledge.

Each student is an individual; therefore the classroom must be flexible to meet the individual needs of each student. Opportunities must be provided for all students to achieve success so that they may

feel good about themselves and, in turn, feel good about science. Teachers may choose to keep their classrooms open before and after school and over the noon hour so that students may work on assignments or lab activities. They may even find their students coming in to work on activities for other classes or utilize reference materials.

Regularly displaying student work is recommended. "Open House" days may involve not only displays but also selected student demonstrations for parents and family members to observe. Such demonstrations give parents an idea of some of the "hands-on" activities in which their children are involved.

In the classroom itself, laboratory groups may be transformed into "assist" or "brainstorming" groups, encouraging a peer-to-peer approach to experimentation and learning rather than a strict teacher-to-student relationship. What students study is often not as important as how they study it. Students need to become involved in problem solving, using logic and common sense. Teachers must ask themselves if their students think and make decisions or just go through the traditional classroom routine.

An Effective Teaching Method

Science teachers must direct their teaching methods towards the students' natural learning styles. Students need time to explore and experiment with science materials and to ask questions about them. When this is allowed, the attention span of the student increases. Some guidance and direction must be provided by the teacher, but this should be a minor part of the instruction. Students need to become involved in experimenting and discovering on their own.

Observers have noted that maturing children sometimes lose their zeal for inquiry. Some teachers' tendency to assume authoritarian views of knowledge, emphasizing the assimilation of predigested information, may be a factor in this loss (NSSE, 1947). Creativity is a process that takes place in the actions of an individual; it cannot be taught. Teachers and school administrators should work together to provide a curriculum that will enhance and reinforce creative environments, and the teachers must provide situations in the classroom that require imagination, invention, originality and problem solving.

Science must be exciting so students will want to come to class every day. Students will learn as much (if not more) in a creative science class as they do in other subjects, but they will do it in such a manner that they will not often realize that they are really working at it.

Curriculum Development

Teachers benefit by developing their own curricula, taking the best ideas from many programs and putting them together with their own. This creates a program that is challenging as well as interesting and

enjoyable for a specific body of students. Teachers must put their units together in logical sequences so that each unit builds on the preceding one. They may find that numerous opportunities arise during the year for exploration in "unplanned" areas.

In any curriculum, however, teachers must not simply feed the facts to the students. Rather, we must teach the students how to discover the facts. Why show a picture of mold and give a lecture about it when students can grow their own and discover its properties through carefully structured observation and experimentation exercises? Why lecture on food chains when students can brainstorm to discover their own? Students must be challenged to develop skills and attitudes and, thus, grow as people.

Conclusion

In a classroom in which creativity is promoted, the teacher as well as the students looks forward to class each day. Students are challenged and the science classroom becomes a stimulating environment. Students become able to solve problems for which there are no simple answers. They do so by reading, investigating, discussing and testing. They are aware that they will succeed as well as fail, but they know that they must seek to perform at the highest level they can attain.

The following suggestions may help teachers to develop creative curricula and styles of teaching in their science classrooms:

* Recognize that nonconformity may be an asset. Allow for flexibility and freedom when students want to investigate and experiment.
* Give positive recognition when students show creativity.
* Recognize students' abilities as problem-solvers.
* Provide opportunities for students to learn that there are several ways of looking at a problem and possibly several methods of finding an answer to it (Hilgard, 1959).
* Keep students from becoming bored by providing activities.
* Encourage inquiry and discovery (Suchman, 1966).
* Realize that working independently is as important as working with a team.
* Allow students to take their time on project work.
* Give students as many opportunities as possible to participate and do experiments.
* Give students choices in order to develop creativity.
* Recognize that all students do not have to do the same activity at the same time.
* Alter the manner of teaching so that all students have the opportunity to become high achievers (Torrance and Storm, 1965).
* Vary the method of instruction and emphasize experimentation, demonstration and inquiry methods of teaching.
* Reinforce the attitude that it is better to try and fail than not to try at all.
* Display creative work.

* Encourage brainstorming to allow students to build on ideas (Piaget, 1963).

Science offers students the opportunity to observe, hypothesize, experiment and arrive at self-attained conclusions. Teaching science must be done in such a manner so that all students share this opportunity equally and so students will be required to utilize their own creativity in searching for solutions. The students will, in turn, be able to apply their creative thought processes not only to science but to everyday problems.

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